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Oil, Agriculture, and the Public Sector

Linking Intersector Dynamics in Ecuador

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Abstract

In a recent paper, Fiess and Verner (2000) analyse sectoral growth in Ecuador and find significant long-run and short-run relationships between the agricultural, industrial and service sectors. They take this as evidence against the dual economy model which rules out a long-run relationship between agricultural and industrial output and show further that a more detailed picture of the growth process can be discovered, once the agricultural, industrial and service sectors are disaggregated further into intrasector components. This paper extends their initial results and provides insight from a multivariate cointegration analysis of intrasector components. We are able to identify three cointegrating relationships, each of which has its own meaningful economic interpretation: Two cointegration relationships capture the direct and indirect effects of the "petrolization" of the Ecuadorian economy. A third relationship clearly indicates a link between agriculture and industrial activity. Since this third cointegrating relationship seems to coincide in time with the trade liberalisation at the end of the 1980s, promoting agriculture appears to be an important way to promote sustainable economic growth in Ecuador.

1. Introduction

In a recent paper, Fiess and Verner (2000) analyse sectoral growth in Ecuador and find significant long-run and short-run relationships between the agricultural, industrial and service sectors. They take this as evidence against the dual economy model which rules out a long-run relationship between agricultural and industrial output. Fiess and Verner (2000) show further that a more detailed picture of the growth process can be discovered, once the agricultural, industrial and service sectors are disaggregated further into intrasector components.

Their bivariate cointegration tests between intrasector components indicate two interesting findings. First, while many sectors share bivariate cointegration vectors, stable cointegration relationships appear only to form from the early 1990s onwards. Second, while there appears to be no direct link between the oil sector and the non-oil industrial sector, there is strong evidence for cointegration between the oil industry and financial services as well as between the oil industry and public services. Since financial services and public services are found to be well interlinked with most other sector components, this underlines that the oil sector cannot be excluded from an intersector growth analysis since an adverse shock to the oil industry might affect the other sectors via the financial and/or the public sector.

While bivariate cointegration tests are useful in identifying basic lines of causality, a multivariate cointegration analysis is able to explore the different direct and indirect inter and intrasector dynamics within a system of equations. It is therefore the aim of this paper to extend the research by Fiess and Verner (2000) with such an analysis.

The remainder of this paper is organised as follows. Section 2 describes the data and the econometric methodology. Section 3 presents the empirical findings and, finally, section 4 presents the main conclusions.

2. A country profile of Ecuador

The nationalisation of the oil industry in 1972 and the oil boom in the 1970s turned Ecuador from a poor, primary-export dependent economy into a middle-income country with a stock of wealth in the form of oil reserves.

The industrialisation strategy of the 1970s was highly protective in nature and led to a capital-intensive industry, which produced inefficiently when compared internationally. As a result, most capital goods, for the purpose of investment, as well as most intermediate goods were imported, while the domestic capital goods production remained small and concentrated in low-technology intensive processes. In the years prior to the debt crisis Ecuador imported more than two-thirds of all installed machinery (see Hentschel, 1994).

The outbreak of the debt crises in 1982, which halted international capital flows to most developing countries, brought for Ecuador a high degree of macroeconomic instability, which persisted through the majority of the 1980s. The economy was further disrupted by a major earthquake in 1987, which destroyed the national oil pipeline and halted oil exports for 5 months.

The end of the 1980s brought a change in the development model towards export-diversification and trade liberalisation, with the result of a rapid and comprehensive trade liberalisation between 1989 and 1992 and the adoption of the common external tariff of the Andean Group. The late 1980s and early 1990s also saw a substantial reduction in public consumption, the elimination of many implicit and explicit state subsidies and a liberalisation of interest rates (see Marconi and Samaniego, 1995).

Even though Ecuador's economy is highly concentrated, with oil, bananas and shrimps representing the major export commodities, the recent trade liberalisation brought a slight change in the structure of Ecuador's exports. While the three major export commodities accounted for 85% of aggregate exports in the late 1980s and early 1992, their combined share dropped to 70% in 1996-97 (Michaely, 1999). According to Michaely (1999), the export diversification of Ecuador has been dominated by processed goods which are intimately related to natural resources such as marine products or raw or processed food products and not by industrial exports.[1] This underlines the general importance of the agricultural sector for the development of other sectors and as a potential source of growth in Ecuador.

[1] Table A6 in the appendix lends further evidence to this point and shows that exports are mainly primary or semi-industrialized.

Table 1

	1973	1980	1990	1998
Agriculture	**18.09**	**14.36**	**17.67**	**17.28**
Industry	**39.22**	**33.80**	**31.74**	**32.96**
- Oil	19.38	10.21	11.81	13.52
- Manufacturing	14.11	18.16	15.45	15.48
- Electricity	0.67	0.76	1.53	1.40
- Construction	5.07	4.68	2.94	2.56
Services	**40.14**	**50.02**	**48.96**	**48.67**
- Commerce	12.39	14.66	13.35	13.52
- Transport	4.53	6.11	6.17	6.25
- Financial	2.22	3.88	2.36	3.55
- Other (non-governmental)	14.27	16.08	18.25	18.53
- Government	6.72	9.29	8.82	6.81

Source: Banco del Ecuador

3. Methodology

3.1 Data and Methodology

Data Description

The data used in this study consists of quarterly data for real GDP from 1973 to 1998 for agriculture, manufacturing, oil, transportation and communications, commerce, financial services and public services (104 observations per time series). The data was provided by the Banco del Ecuador. All series were log-transformed.

Table 1 presents the contribution of the different sectors in percentage shares of total GDP at various points in time. When comparing the contribution of the sectors to the total GDP across time, it appears that the weight of the agricultural sector declined from 25.8% in 1965 to 17.3% in 1998, while the industrial sector managed to increase its share in the same time from 22.3% in 1965 to 33% in 1998. Once we disaggregate the industrial sector, we find that the increasing weight of the industrial sector can be largely attributed to the oil industry. The share of the manufacturing sector appears to have remained largely constant, averaging around 15% of total GDP, while construction effectively reduced its share in total GDP from 6.5% to 2.6%.

The aggregated service sector managed to keep a constant share of total GDP of just below 50%. However, the disaggregation of the service sector shows a different picture. While the weight of public sector services declined from 8.1% in 1965 to 6.8% in 1998, the financial service sector managed to more than double its contribution to total GDP from 1.7% in 1965 to 3.6% in 1998. The transport sector also steadily increased its share in total GDP from 4.0% in 1965 to 6.3% in 1998.

Methodology

We use the multivariate Johansen approach (1988) to explore possible cointegration relationships in the data. We intend to interpret cointegration as evidence for interdependence between the different sectors and propose to explore the dynamics and linkages between the sectors further by estimating dynamic models which incorporate short- as well as long-run information.

The Multivariate Cointegration Analysis of Johansen

The Johansen procedure allows us to test for cointegration in a multivariate system. Starting from an unrestricted vector autoregressive model (VAR), the hypothesis of cointegration is formulated as a hypothesis of reduced rank of the long run impact matrix Π (Johansen, 1988, Johansen and Juselius, 1990). The VAR is generated by the vector z_t, which defines the potential endogenous variables of the model. Taking first differences of the variables, the VAR can be transformed into an error correction model

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_{k-1} \Delta z_{t-k=1} + \Pi z_{t-k} + \psi D_t + \varepsilon_t , \qquad \varepsilon_t \sim IN(0, \Sigma)$$

where the estimates of $\Gamma_i = -(I - A_1 - \ldots - A_i), (i = 1, \ldots, k-1)$ describe the short run dynamics to changes in z_t and $\Pi = -(I - A_1 - \ldots - A_i)$ captures the long run adjustments and D contains deterministic terms.

Cointegration occurs in the case of reduced rank of Π. Only if the rank is reduced (r<n) is it possible to factorise Π into $\Pi \ (= \alpha\beta')$ where α denotes the adjustment

coefficients and β the cointegration vectors. The cointegration vectors β have the property that $\beta' z_t$ is stationary even though z_t itself is non-stationary.

If the rank is reduced it is possible to interpret the VAR in first differences as a vector error correction model and to obtain estimates of α and β via the reduced rank regression. Since the rank of Π is equal to the number of independent cointegration vectors and the rank of Π is also equal to the number of non-zero eigenvalues, the test of cointegration thus amounts to a test for the number of non-zero eigenvalues. The trace statistics, λ_{trace}, is a non-standard distributed likelihood-ratio test, which is commonly used to determine the number of cointegration vectors, (Johansen, 1988). The trace statistic tests the null hypothesis that there are at most r cointegration vectors:

$$H_0\text{: } \lambda_i = 0, \text{ for i = r+1,..n}$$

where only the first r eigenvalues, λ, are non-zero against the unrestricted hypothesis that r = n.[2]

It is now common practice to try to identify the cointegration space and we follow the approach outlined in Johansen (1992) and Johansen and Juselius (1994). According to Johansen (1992) and Johansen and Juselius (1994) a system is exactly or just identified if $k = r - 1$ restrictions are placed on each cointegration vector and the rank condition for generic identification is satisfied.[3]

If more than $k = r$-1 restrictions are placed on each cointegration vector then it is possible to test with an LR test whether these over-identifying restrictions are valid and thus restrict the variation of the parameters. If the over-identifying restrictions satisfy the rank condition and the LR test is passed successfully then each cointegration vector is said to be uniquely identified.

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[2] The null hypothesis of at most r cointegration vectors implies that there are n-r unit roots and, theoretically, n-r zero eigenvalues. This is because the hypothesis of cointegration is formulated as the reduced rank of $\Pi = \alpha\beta'$ and the full rank of $\alpha_\perp{}'\Gamma\beta_\perp$, where α and β are $n \times r$ matrices and $\alpha_\perp$ and $\beta_\perp$ are n$\times$*(n-r)* matrices orthogonal to α and β. This allows us then to distinguish between r cointegrating I(0) relations and n-r non-cointegrating I(1) relations.

[3] In the case of two cointegration vectors generic identification requires that the rank condition $rank(R_i' H_j) \geq 1$ for $i, j = 1, 2$ and $i \neq j$ is fulfilled. Where R_i is the orthogonal complement of H_i, such that R_i and H_i are both of full rank and satisfy the conditions $R_i' H_i = 0$, $R_i' \beta_i = 0$ and $\beta_i = H_i\, \varphi_i$. R_i are $p*k$ matrices and H_i are $p*s$ matrices with $k + s = p$.

4. Empirical Findings

4.1 Evidence of Cointegration

Our sectoral growth VAR model includes a constant in the cointegration space and 4 lags of each of the 6 variables.[4] This is sufficient to produce random errors.[5]

Table 2

Null Hypothesis	Alternative Hypothesis	Lag: 4 With Constant	95% Critical Value	90% Critical Value
λ_{trace} test				
$r = 0$	$r > 0$	220.97	131.70	126.58
$r \leq 1$	$r > 1$	147.97	102.14	97.18
$r \leq 2$	$r > 2$	84.08	76.07	71.86
$r \leq 3$	$r > 3$	44.13	53.12	49.65
$r \leq 4$	$r > 4$	21.96	34.91	32.00
$r \leq 5$	$r > 5$	6.77	19.96	17.85
$r \leq 6$	$r > 6$	2.30	9.24	7.52

*Rejection at the 5% level of significance
Source: Authors' calculations.

The estimates of the trace test statistics, λ_{trace}, which test the hypothesis of less than or equal to r cointegrating vectors are reported in Table 2. The number of cointegrating vectors is determined by starting at the top of Table 2 and moving down until H_0 cannot be rejected. Since the trace statistics is the first time not rejected for the null hypothesis of $r \leq 3$, there appears to be evidence for three cointegrating relationships between the six intrasector components.

Table 3 contains general model specification tests and indicates that our model appears to be well specified for three cointegrating vectors.

[4] We also estimated a model where we included construction as a 7th variable. However, an LR test indicated that construction can be excluded from the model without loss of generality. ($\chi^2(1) = 5.46$, $p = 0.14$).

[5] The model specification is presented in the appendix in Table A3. The diagnostics on the residuals of the system show the absence of autocorrelation but indicate some non-normality. Since Cheung and Lai (1993) have shown that the trace-test is robust to both skewness and excess kurtosis, we decided to estimate the model with this specification.

Table 3

TEST FOR EXCLUSION: LR TEST χ^2 (r)											
r	dgf	$\chi^2(n)$	agri	manu	Trans	com.	fin.	gov	oil	const.
1	1	3.84	8.95	14.68	3.52	0.04	4.75	1.62	1.40	11.33
2	2	5.99	8.97	16.32	7.39	0.17	22.63	19.67	17.96	25.14
3	3	7.81	10.20	16.51	20.43	11.10	25.18	32.63	27.20	37.58
4	4	9.49	11.13	17.17	23.90	16.91	25.35	38.67	33.97	38.00
5	5	11.07	11.77	17.54	23.93	19.99	26.16	39.77	36.67	38.01
6	6	12.59	19.80	27.17	33.54	28.65	35.79	45.30	45.55	47.60
TEST FOR STATIONARITY: LR TEST χ^2 (p-r)										
r	dgf	$\chi^2(n)$	agri	manu	Trans	com.	fin.	gov	oil	
1	7	14.07	50.66	50.47	50.68	50.61	50.73	50.31	50.70	
2	6	12.59	35.72	35.53	35.72	35.66	35.77	35.37	35.82	
3	5	11.07	18.24	18.04	18.23	18.17	18.40	17.89	18.51	
4	4	9.49	5.26	5.05	5.24	5.19	5.41	4.90	5.50	
5	3	7.81	3.75	3.61	3.75	3.70	4.07	3.44	3.89	
6	2	5.99	3.75	3.60	3.74	3.69	4.05	3.43	3.89	
TEST FOR WEAK-EXOGENEITY: LR TEST χ^2 (r)										
r	dgf	$\chi^2(n)$	agri	manu	Trans	com.	fin.	gov	oil	
1	1	3.84	0.36	0.64	5.75	3.85	0.82	8.05	0.53	
2	2	5.99	0.38	0.67	9.81	3.89	18.36	26.09	16.91	
3	3	7.81	6.85	4.58	11.39	14.38	24.58	36.53	19.02	
4	4	9.49	12.65	6.05	17.77	18.08	24.99	38.96	24.40	
5	5	11.07	14.03	7.44	20.86	18.53	28.00	41.78	26.24	
6	6	12.59	23.62	15.73	25.37	18.97	37.58	44.31	33.98	

Note: For r = 3, the test of long-run exclusion shows that none of the variables can be excluded from the cointegration space and the tests for stationarity indicate that none of the variables can be considered stationary. The tests of weak exogeneoity indicate that for r =3 that *manufacturing* could be treated as weakly exogeneous.

Normalising the first cointegration vector on the 2nd and the second and the third cointegration vector on the 3rd element, yields the following estimates for β_1, β_2 and β_3 (Table 4) and α_1, α_2 and α_3 (Table 5):

Table 4

	β_1	β_2	β_3
Agr	0.296	-0.014	-0.110
Manu	1.000	0.090	-0.093
Transp.	-0.644	1.000	1.000
Commerce	-0.048	-0.155	-0.888
Fin.	-0.136	-0.257	-0.014
Gov.	0.255	-1.028	-0.085
Petrol	-0.051	-0.218	0.035
Constant	-6.716	4.981	2.105

Source: Authors' calculations.

Table 5

	α_1	α_2	α_3
Δ *Agr*	-0.038	-0.006	**0.260**
	(-0.78)	(-0.19)	(3.83)
Δ *Manu*	-0.042	0.006	**-0.159**
	(-0.94)	(0.20)	(-2.51)
Δ *Transp.*	**-0.152**	**-0.068**	-0.098
	(-3.24)	(-2.04)	(-1.49)
Δ *Commerce*	**-0.151**	-0.012	**0.323**
	(-2.51)	(-0.27)	(3.80)
Δ *Fin.*	**0.303**	**0.727**	-0.196
	(-1.77)	(5.93)	(-0.81)
Δ *Gov.*	**-0.446**	**0.248**	0.070
	(-5.88)	(4.57)	(0.65)
Δ *Petrol*	0.695	**2.019**	-0.558
	(1.33)	(5.41)	(-0.76)

Note: Δ indicates a variable in first differences.
Source: Authors' own calculations.

The columns of β s' are the cointegrating parameter vectors or, in other words the β s' spans the cointegration space. The coefficients of the α s' can be interpreted as adjustment coefficients measuring the relative importance of a deviation from equilibrium on a given endogeneous variable.

4.2 Identifying the Cointegration Space

The significance of the adjustment parameters can be used as a first guideline for identifying cointegration relationships. The first cointegration relationship suggests a relationship between the public sector, the non-oil industrial sectors and private service sector components. Agriculture and oil do not seem to be part of this first cointegration relationship, since the agricultural sector and the oil sector enter the cointegration relationship with a coefficient close to zero and further have insignificant adjustment coefficients.

The second cointegration relationship seems to be centred around oil sector and the public sector. This relationship could be interpreted as a "petrolization" equation describing the capitalization of the public sector through rent from nationalised oil production.[6] The fact that transportations and communications seem to be also part of this equation is interesting since it confirms arguments brought forward by Sierra (1998) that transportation and communications constitute the two productive sectors of the Ecuadorian economy that benefited most from the "petrolization" of the Ecuadorian economy. The reason that transport and communications are part of this cointegration relationship could indicate that these productive sectors benefited directly – as described in Sierra (1998) - through the availability of subsidised combustibles. The first cointegration relationship - centred around the public sector - could then well be indicative for the indirect dissemination of oil-dollars to the rest of the economy through direct subsidies and subsidised loans as well as development programs from the Government as laid down in the different *Leyes de Fomento*.

The third cointegration relationship is interesting for two reasons. First, there appears to be a link between agriculture, manufacturing and commerce and second as a recursive cointegration analysis shows (Figure 1), it only appears to be stable from the 1990s onwards.

The link between agriculture, manufacturing and commerce is an interesting finding since advocates of the dual economy model generally rule out significant forward and backward linkages between agriculture and industrial output. The dual economy model originating in Lewis (1954), Fei and Ranis (1961) and Sen (1966) seeks to explain economic growth by emphasising the roles of agriculture and industry and the interplay between them. The dual economy model views the agricultural sector as the basis of an emerging economy, a generator of the capital necessary for take-off towards the second stage of economic development: industrialisation. Once industrialisation has taken place, the agricultural sector becomes gradually a mere appendage to the economic system, with no internal economic integration and a low degree of intersector linkages.

Recent developments in the sectoral growth literature dispute this view of the dual economy model. Mellor and Lele (1970), Mellor (1972), Johonston and Kilby (1975) argue that a virtuous cycle between agricultural intensification and non-agricultural activity could emerge on the basis of production and consumption linkages. An increased

[6] In the 1980s much has been written about the dominant influence of oil industry on economic growth and development as well as on the social and political institutions of developing nations. The term "petrolization" was coined to described the structural changes introduced by increasing petroleum production. (see e.g. Mallakh et al.. 1983)

demand of farmers for inputs such as machinery and machinery repair can stimulate non-agricultural activity through backward linkages. Non-agricultural activity could be stimulated by agriculture at the same time via forward linkages such as the requirement to process agricultural products through spinning, milling or canning.

Gopinath, Roe and Shane (1996) analyse the possible link between agriculture and food processing and find that productivity gains in agriculture feed back into the food processing industry, where they lead to cheaper inputs. Lower priced inputs lead in turn to increased derived demand for primary agricultural products, thus partly mitigating the price decline. The two sectors evolve interdependently over time, contrary to what the dual economy model predicts.

Further, sectoral studies of growth find long-run relationships and short-run causality between the industrial, agricultural and service sectors in Côte d'Ivoire, Ghana and Zimbabwe (Blunch and Verner (1999) and Ecuador (Fiess and Verner (2000)).

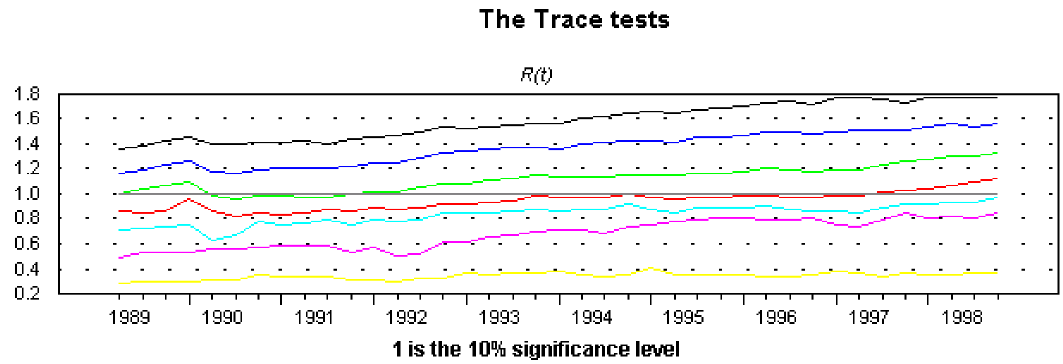
The dual economy literature generally rules out two major issues about the later stages of development. First, the literature denies that agriculture may be an important growth-promoting factor. Second, it rules out feedback mechanisms between agriculture and industry.

As already mentioned, we find that this third cointegration relationship appears to be stable only from the 1990s onwards,

Figure 1 shows the results of a recursive cointegration analysis, where the trace-statistics for the hypothesis of cointegration vector is estimated for different sample periods.

Operationally, the data from 1973:Q1 to 1988:Q1 is used as a base period for the calculation of the first test-statistic and the sample size is then successively increased by one observation at a time until the end of the sample.

Figure 1: Recursive Trace Test



The corresponding trace-statistics for different ranks are plotted in Figure 1. The graph is scaled such that unity corresponds to the 10% level of significance. As can be seen from Figure 1, the first two cointegration vectors appear to be stable over the whole sample, however the third only becomes significant from the 1990s onwards.

It is interesting to note that the stability of the third cointegration vector coincides with the trade liberalisation at the end of the 1980s, which led to an export diversification that has been dominated by processed goods which are intimately related to natural resources such as marine products or raw or processed food products and not by industrial exports Michaely (1999).[7] This underlines the general importance of the agricultural sector for the development of other sectors and as a potential source of growth in Ecuador.

4.3 Testing Restrictions

As a more formal way of identifying the cointegration space we place restrictions onto the cointegration space. Table 6 reports hypotheses tests if a specific variable can be excluded from the cointegration space. Since H_1 to H_8 cannot be rejected, none of the variables can be exclude from the cointegration space. While therefore all variables are needed to form the cointegration space, Table 5 indicates that this need not to be the case for the individual cointegration vectors. In an attempt to identify the cointegration space we therefore place individual restrictions on the three different cointegration vectors.

[7] Table A6 in the appendix lends further evidence to this point and shows that exports are mainly primary or semi-industrialized.

Table 6: Restricting the cointegration space

	Agr	Manu	Trans	Com	Fin	Gov	Oil	Const	LR-test	p-value
H1	0	1	*	*	*	*	*	*	$\chi^2(3) = 12.97$	0.00
H2	1	0	*	*	*	*	*	*	$\chi^2(3) = 16.51$	0.00
H3	1	*	0	*	*	*	*	*	$\chi^2(3) = 22.26$	0.00
H4	1	*	*	0	*	*	*	*	$\chi^2(3) = 26.78$	0.00
H5	1	*	*	*	0	*	*	*	$\chi^2(3) = 28.14$	0.00
H6	1	*	*	*	*	0	*	*	$\chi^2(3) = 21.09$	0.00
H7	1	*	*	*	*	*	0	*	$\chi^2(3) = 27.20$	0.00
H8	1	*	*	*	*	*	*	0	$\chi^2(3) = 36.77$	0.00

Note: Table 6 summarises the findings of different hypotheses tests on the coefficients of α and β. A 0 indicates that the coefficient of a variable, i, has been restricted to zero and is equivalent to a test of long-run exclusion, a 1 indicates the variable used for normalisation and a * indicates that a variable has been left unrestricted. All tests are joint tests for long-run exclusion and weak exogeneity, i.e., $\alpha_i = \beta_i = 0$.
All tests are likelihood ratio (LR) tests which are distributed as χ^2, conditional upon the rank and the number of restrictions imposed.

Based on consideration in section 3.2, we interpret the second cointegration vectors is a "petrolization" equation that links oil with the public sector, the financial sector and the transport sector. We attempt to interpret the first cointegration relationship as a "traditional" fiscal relationship that links the public sector with non-oil productive activity. The third cointegration vector is interpreted as a link between agriculture, manufacturing and commerce.

Guided by these assumptions, we impose different restrictions on the cointegration space. The basic test is formulated in the following way:

$$H_1' = \begin{vmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{vmatrix}, \; H_2' = \begin{vmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{vmatrix} \text{ and } H_3' = \begin{vmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{vmatrix}$$

This corresponds to a test that excludes agriculture and oil from the first cointegration relationship; agriculture, manufacturing and commerce from the second cointegration relationship; and transport, public services and oil from the third cointegration vector, imposes two restrictions on the first and three restrictions on the second and the third cointegration vector.

The LR test of this model specification has a χ^2 distribution with 2 degrees of freedom. The calculated value of $\chi^2(2) = 2.65$ has a p-value of 0.27. Since the critical value is not significant, H_1 is a possible identification of the cointegration space.

Table 7 contains a summary of different hypotheses tests that represent variations of the basic restriction formulation outlined above. Hypotheses H_1 to H_6 retain the same restrictions on the first cointegration vector, but vary the restrictions on the second and the third. H_7 to H_{12} exclude additionally manufacturing from the first cointegration vector.

Table 7

		Agr	Manu	Trans	Com	Fin	Gov	Oil	Const	LR-test	p-value
H_1	β_1	0	1	*	*	*	*	0	*	$\chi^2(2) = 4.57$	0.10
	β_2	0	0	1	0	*	*	*	*		
	β_3	1	*	0	*	*	0	0	*		
H_2	β_1	0	1	*	*	*	*	0	*	$\chi^2(4) = 15.72$	0.00
	β_2	0	0	1	0	0	*	*	*		
	β_3	1	*	*	0	0	0	0	*		
H_3	β_1	0	1	*	*	*	*	0	*	$\chi^2(2) = 2.65$	0.27
	β_2	0	0	1	0	*	*	*	*		
	β_3	1	*	*	*	0	0	0	*		
H_4	β_1	0	1	*	*	*	*	0	*	$\chi^2(3) = 16.32$	0.00
	β_2	0	0	1	0	0	*	*	*		
	β_3	1	*	0	*	0	0	0	*		
H_5	β_1	0	1	*	*	*	*	0	*	$\chi^2(2) = 19.06$	0.27
	β_2	0	0	1	0	*	*	*	*		
	β_3	1	*	*	*	0	0	0	0		
H_6	β_1	0	1	*	*	*	*	0	*	$\chi^2(4) = 15.72$	0.00
	β_2	0	0	1	0	*	*	*	*		
	β_3	1	*	0	*	0	0	0	*		
H_7	β_1	0	0	1	*	*	*	0	*	$\chi^2(3) = 4.93$	0.18
	β_2	0	0	0	0	1	*	*	*		
	β_3	1	*	*	*	0	*	0	0		
H_8	β_1	0	0	1	*	*	*	0	*	$\chi^2(3) = 3.69$	0.30
	β_2	0	0	1	0	*	*	*	*		
	β_3	1	*	*	*	*	0	0	0		
H_9	β_1	0	0	1	*	*	*	0	*	$\chi^2(3) = 16.32$	0.19
	β_2	0	0	1	0	*	*	*	*		
	β_3	1	*	*	0	0	0	0	*		
H_{10}	β_1	0	0	1	*	*	*	0	*	$\chi^2(4) = 14.93$	0.00
	β_2	0	0	1	0	*	*	*	*		
	β_3	1	*	0	0	0	0	0	*		

H_{11}	β_1 β_2 β_3	0 0 1	0 0 *	1 1 *	* 0 *	* 0 *	* * 0	0 * 0	* * 0	χ^2 (4) = 19.06	0.00
H_{12}	β_1 β_2 β_3	0 0 1	0 0 *	1 1 *	* 0 *	* 0 0	* * 0	0 * 0	* * 0	χ^2 (4) = 5.29	0.26

Note: Table 7 summarises the findings of different hypotheses tests on the coefficients of β of the three cointegration vectors β_1, β_2 and β_3.

H_3, H_5 and H_{12} strongly support an identification of the cointegration space along the theoretical considerations in section 4.2 of a direct petrolization relationship, linking oil, the public sector, the financial sector and transport; an indirect petrolization relationship linking public sector, manufacturing, commerce, financial services and transport; and agricultural based relationship linking agriculture, manufacturing, transport and commerce.

5. Conclusion

While the rapid growth of the oil industry in the 1970s had a huge impact on the Ecuadorian economy and fostered hopes for industrialisation, the recent increase in manufactured export in Ecuador is however not linked to industrialisation but derived from agriculture. In an attempt to identify and model the different forces contributing to sectoral growth in Ecuador, we adopt a novel approach and present a multivariate cointegration analysis of different intrasector component.

We are able to identify three cointegrating relationships, each of which has its own meaningful economic interpretation: Two cointegration relationships capture the direct and indirect effects of the “petrolization” of the Ecuadorian economy. A third relationship clearly indicates a link between agriculture and industrial activity. Since this third cointegrating relationship seems to coincide in time with the trade liberalisation at the end of the 1980s, promoting agriculture appears to be an important way to promote sustainable economic growth in Ecuador.

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